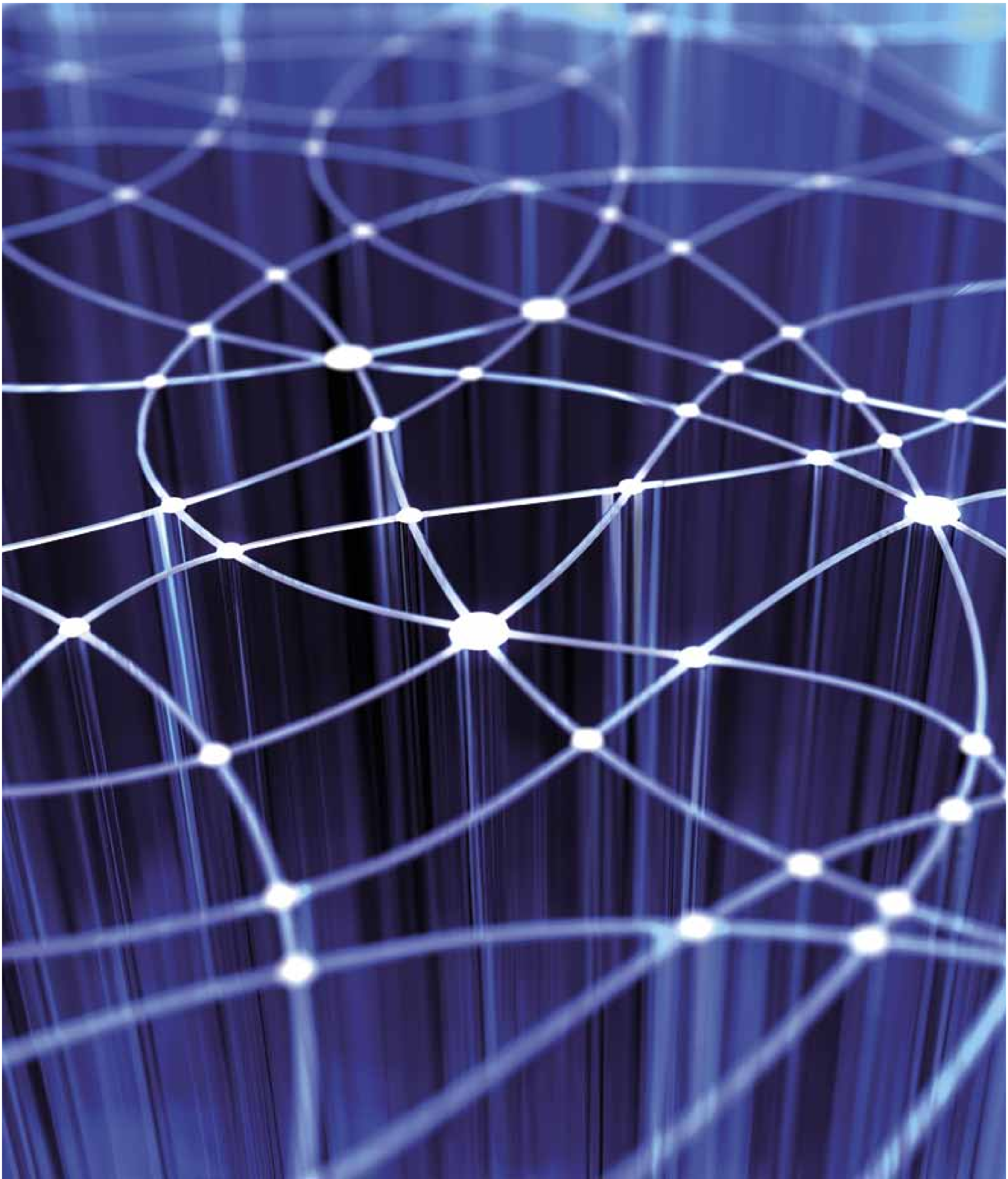

Automotive Engineering

at Ghent University

UNIVERSITEIT
GENT

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Automotive Engineering
at Ghent University

Ghent University is one of the major universities in Belgium. With eleven faculties housing more than 120 departments, Ghent University's research ranges across all disciplinary areas. It extends from (Veterinary) Medicine to Business and Economics, from Psychology to Literature and Philosophy, to Applied Sciences and Engineering, to Politics, Sociology and Law.

Ghent University is a research intensive university. More than 6.000 researchers carry out academic research and offer high-quality courses through the 200 study programs. Their scientific findings are translated into real-life applications, that have clear impact in society.

Ghent University has a long tradition in collaborating with companies. The university has experienced a steady rise in external funding of research, growing to close to 20%, an impressive number according to OECD studies.

This brochure describes the automotive research activities of several departments of the Faculty of Engineering and Architecture, one of the largest faculties of Ghent University.

The several areas are:

- Electrical engines
- Combustion engines
- Mechanical engineering
- Composites
- Production engineering
- Mobility & Intelligent transport systems

STAFF
8602

STUDENTS
35817

GRADUATES
10476

INCOME
€ 524,412,000

Axial flux pm machine

An axial flux permanent magnet machine is a relatively new type of electrical machine with a lot of potential, e.g. as wheel motor. We developed a 4kW prototype with a nominal speed of 2500rpm and rated torque of 15Nm with a simulated resp. measured efficiency of 98% resp. 95%. The prototype includes a number of techniques -some patent protected- to end up with a very efficient, compact and light weight machine (axial length 100mm, outer diameter of 180mm, 8kg).
While prototyping we used our specific know-how and expertise for simulation as well as our software tools.

For further information, contact jeroen.demaeyer@ugent.be

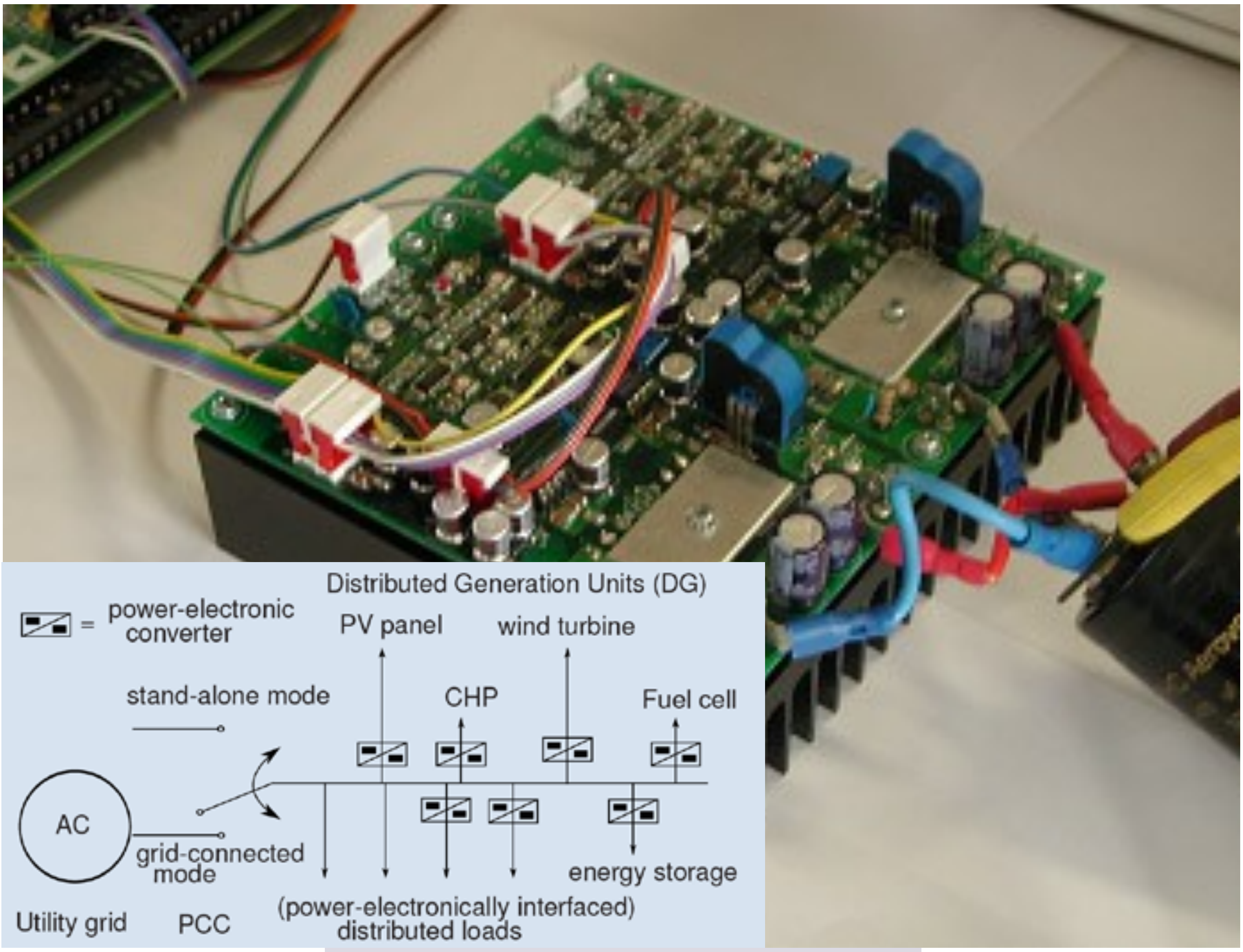
Power electronics

We develop bi-directional power electronics for kinetic energy recovery systems of electrical machines.

We develop control strategies for micro-grids working in island mode populated with decentralised renewable generation units as well as electrical vehicles.

We develop control and balancing strategies for multi-level converters and electrical energy storage in ultra-capacitors.

We develop power electronics that assist in the grid stability and power grid quality.

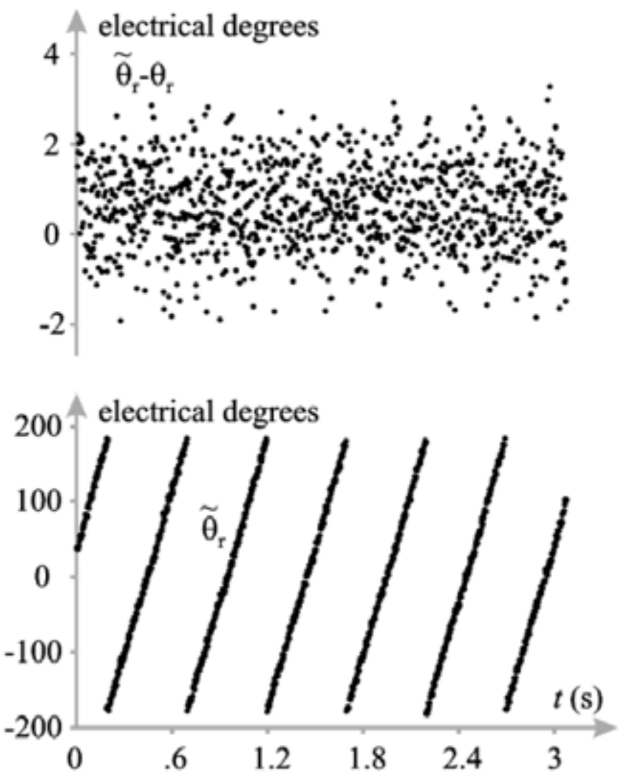


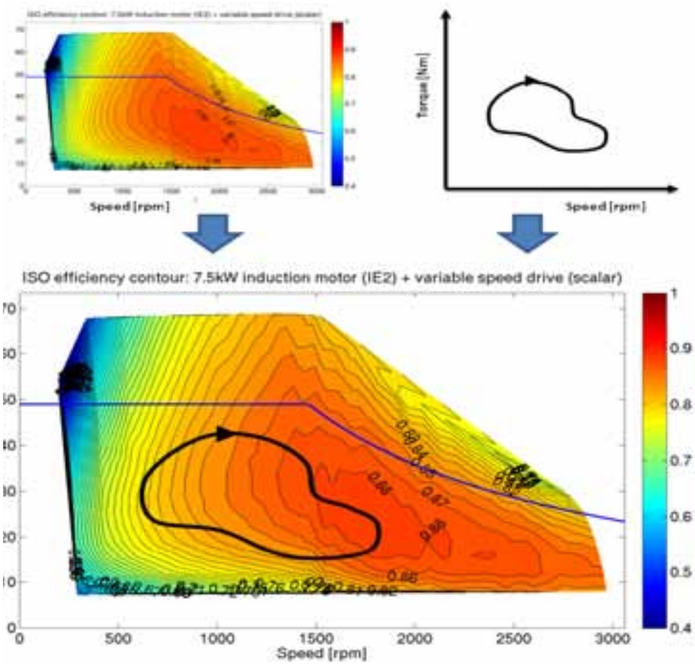
For further information, contact jeroen.demaeyer@ugent.be

Sensorless control of electrical machines

Our patented VASCO method allows to control any salient machine in a sensorless way from stand-still, low speed to high speed. It can be seemlessly integrated in traditional PMW control strategies, not conflicting or corrupting the torque control loop. The accuracy of the sensorless position estimation method has an accuracy of about ± 2 electrical degrees even over different external boundary conditions.

Furthermore, we work on the control of electrical machines using electrical efficiency maps, FPGA implementation of control loops, … using our test infrastructure.

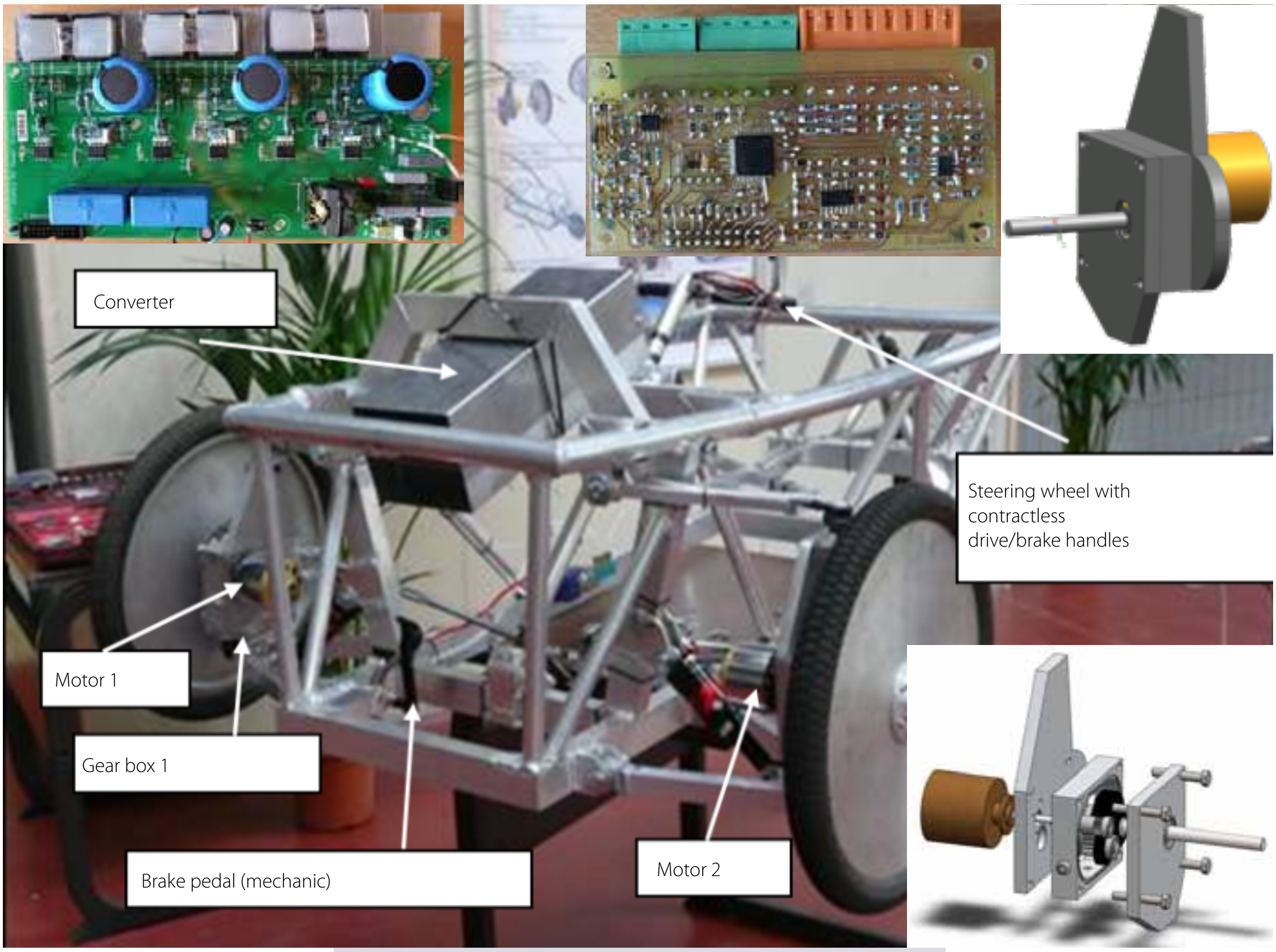




For further information, contact jeroen.demaeyer@ugent.be

Ecological low-budget electric vehicle

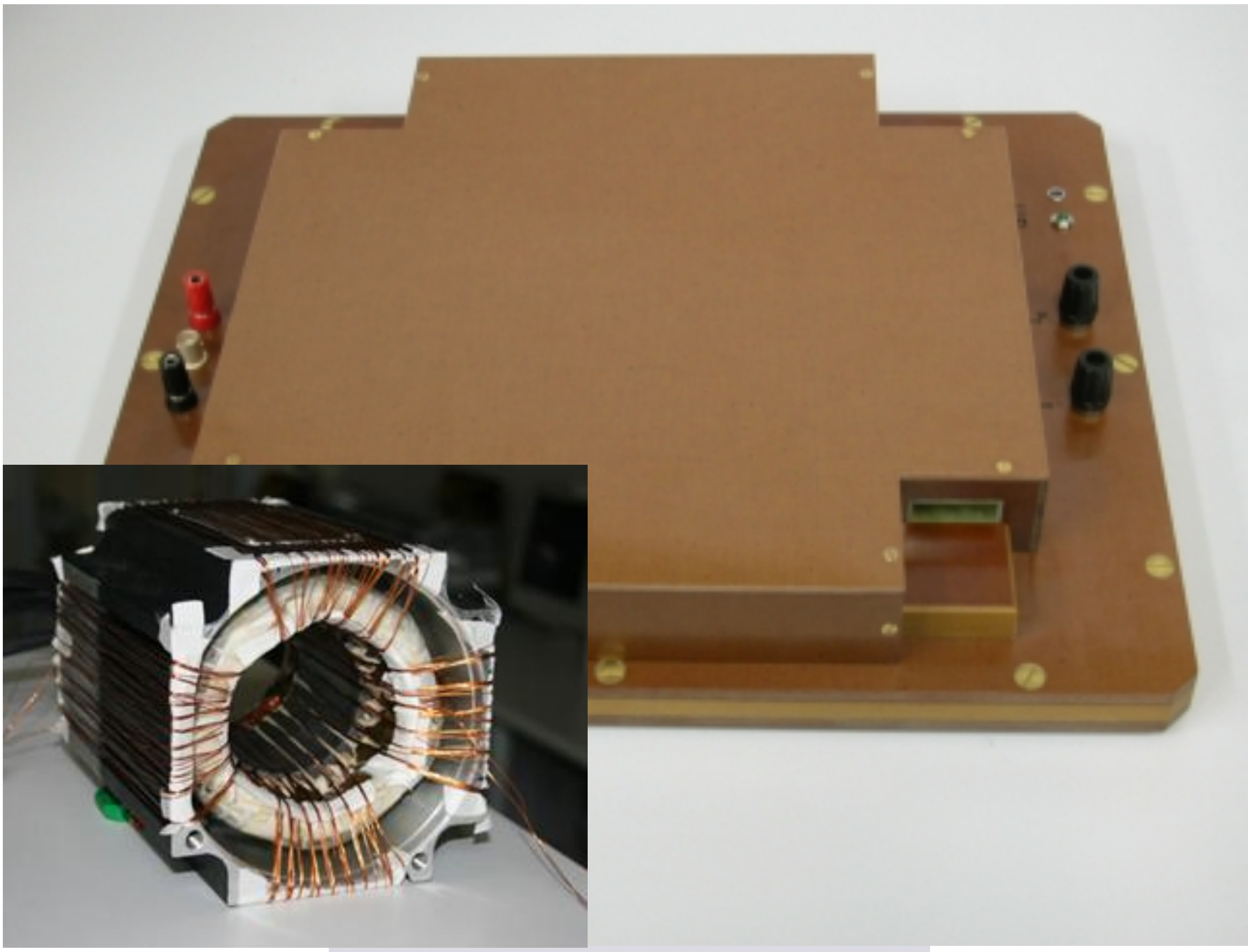
The **ELBEV** (Ecologic Low-Budget Electric Vehicle) is a one-person concept car, it targets low weight and high efficiency. It has two motors, three wheels and weights 100 kg. Maximum speed is 70 km/h.
The drive train consists of two brushless DC wheel motors on the front wheels. An integrated design approach was applied to the motor, gear box, power electronics and CPLD control, including the electromagnetic, thermal and mechanical aspects. An example of this integrated approach is the gear box, which also serves as the king pin and the cooling plate of the motor.



For further information, contact jeroen.demaeyer@ugent.be

In situ characterisation of magnetic materials

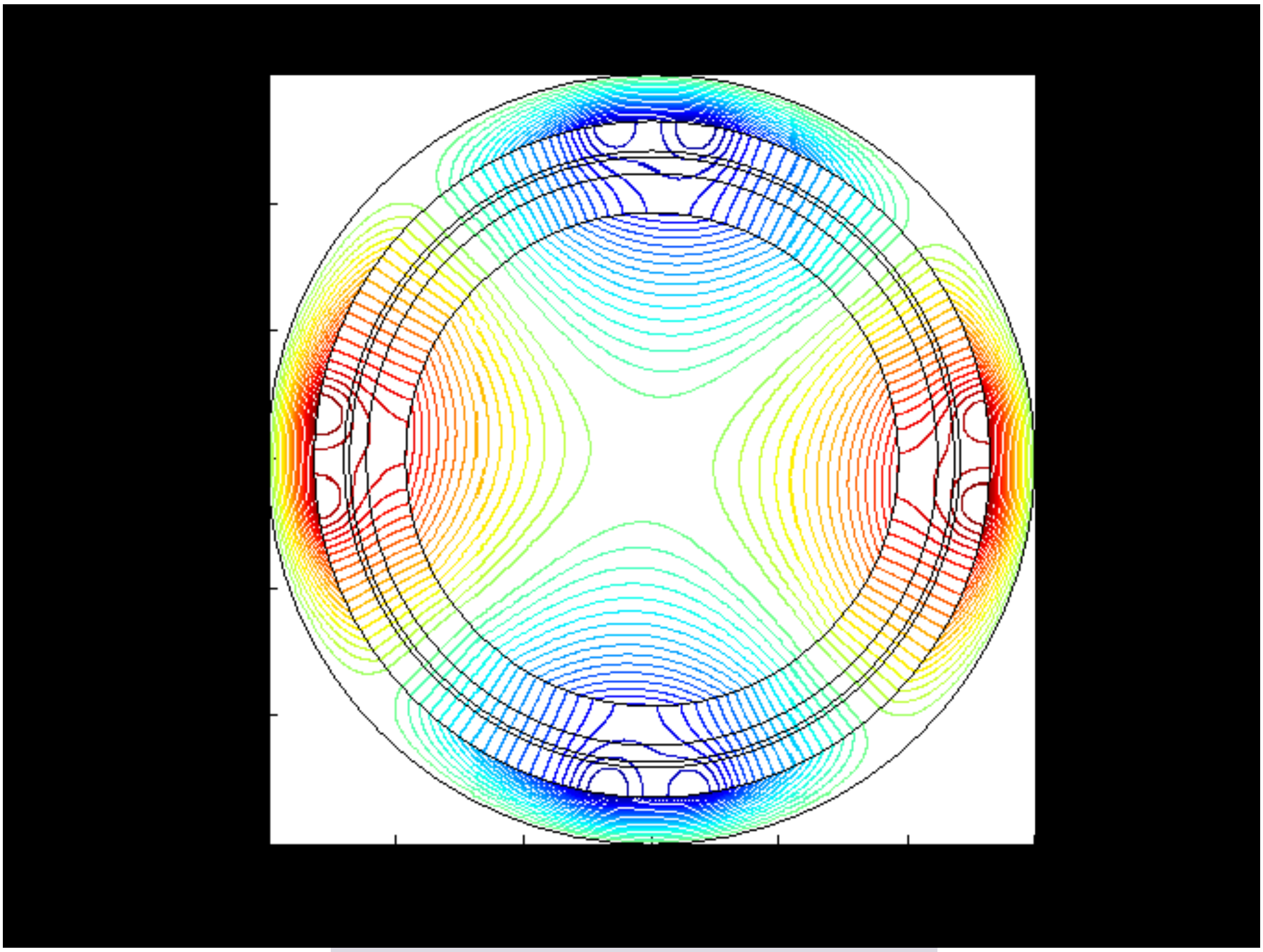
Our laboratories are equipped to perform standardized characterisation on strips outside the machine, using an Epstein frame of single sheet tester with unidirectional or rotational excitation.
Furthermore we developed techniques to determine the material characteristics of the magnetic materials inside the machine. This technique visualises magnetic degradation of the material by cutting of the lamination or by mechanical stress.



For further information, contact jeroen.demaeyer@ugent.be

High speed machines

We develop several analytic models to compare several configurations of high speed machines. These models include analytically solving the vector potential equation. As such we can compute the torque (incl. torque ripple), losses in stator iron (for non-sinusoidal induction waveforms and based on realistic magnetic characteristics), losses in magnets and rotor iron (by harmonics), and efficiency maps, …
Models can be applied to inner/outer rotor, radial flux/ axial flux machines for typical high speed applications such as range extenders and flywheels for KERS systems.



For further information, contact jeroen.demaeyer@ugent.be

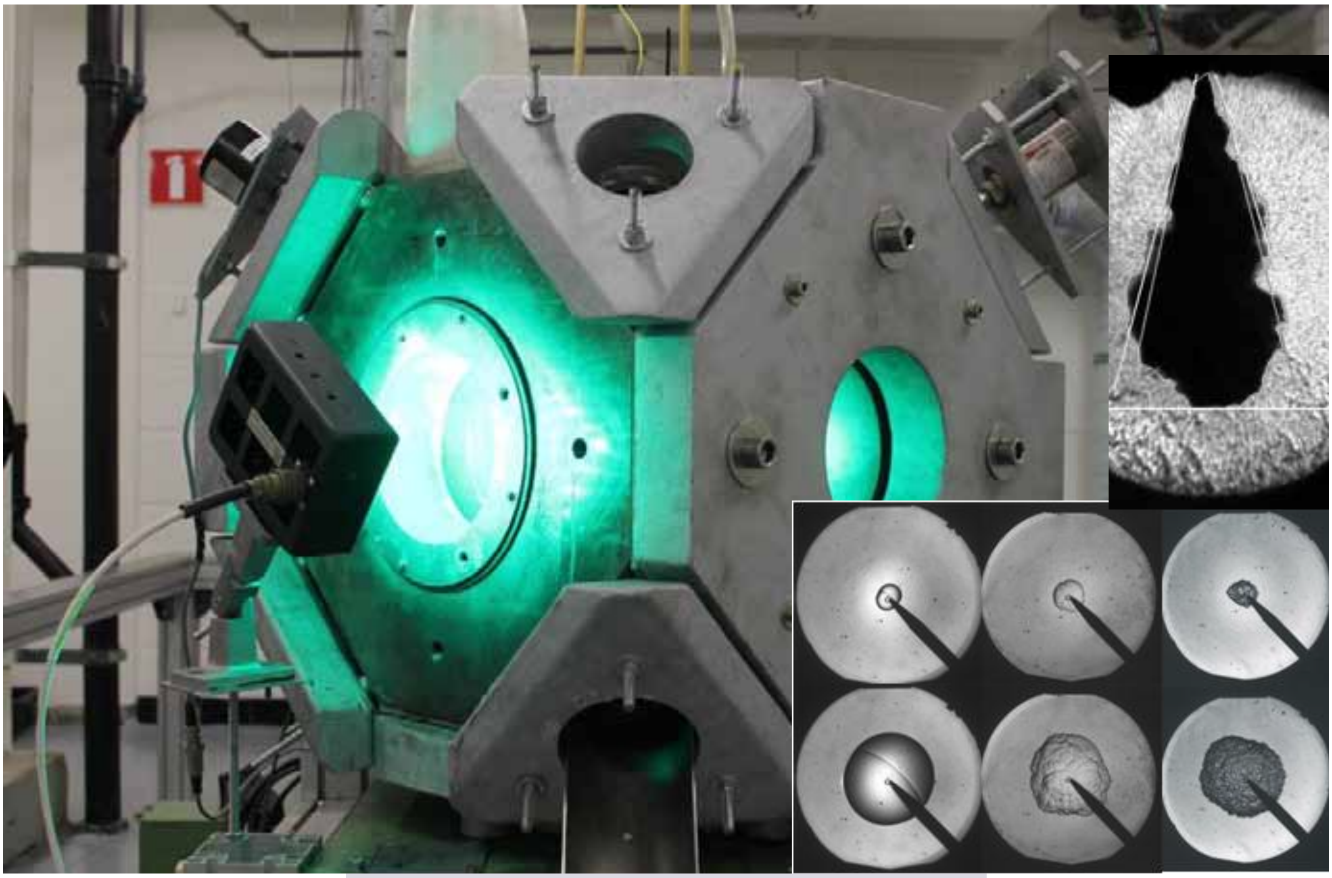
Combustion chamber

The Ghent University Combustion Chamber I (GUCCI) is an experimental optically accessible combustion chamber with the following characteristics:

- Max pressure: 350 bar (currently 100 bar due to quartz windows)
- Electrical preheating to 200°C, higher T's for spray measurements through precombustion technique
- Side or central ignition (flame speed measurement)
- Gaseous or liquid fuels, suitable for highly viscous fuels

The setup is equipped with:

- Instantaneous chamber pressure sensor
- Injection pressure and needle lift sensors
- High speed camera PCO Dimax: 1280 fps at 4 Mpix, up to 100k fps at lower res
- Image intensifier
- High power LED arrays, high speed controllers (>10kHz)



For further information, contact jeroen.demaeyer@ugent.be

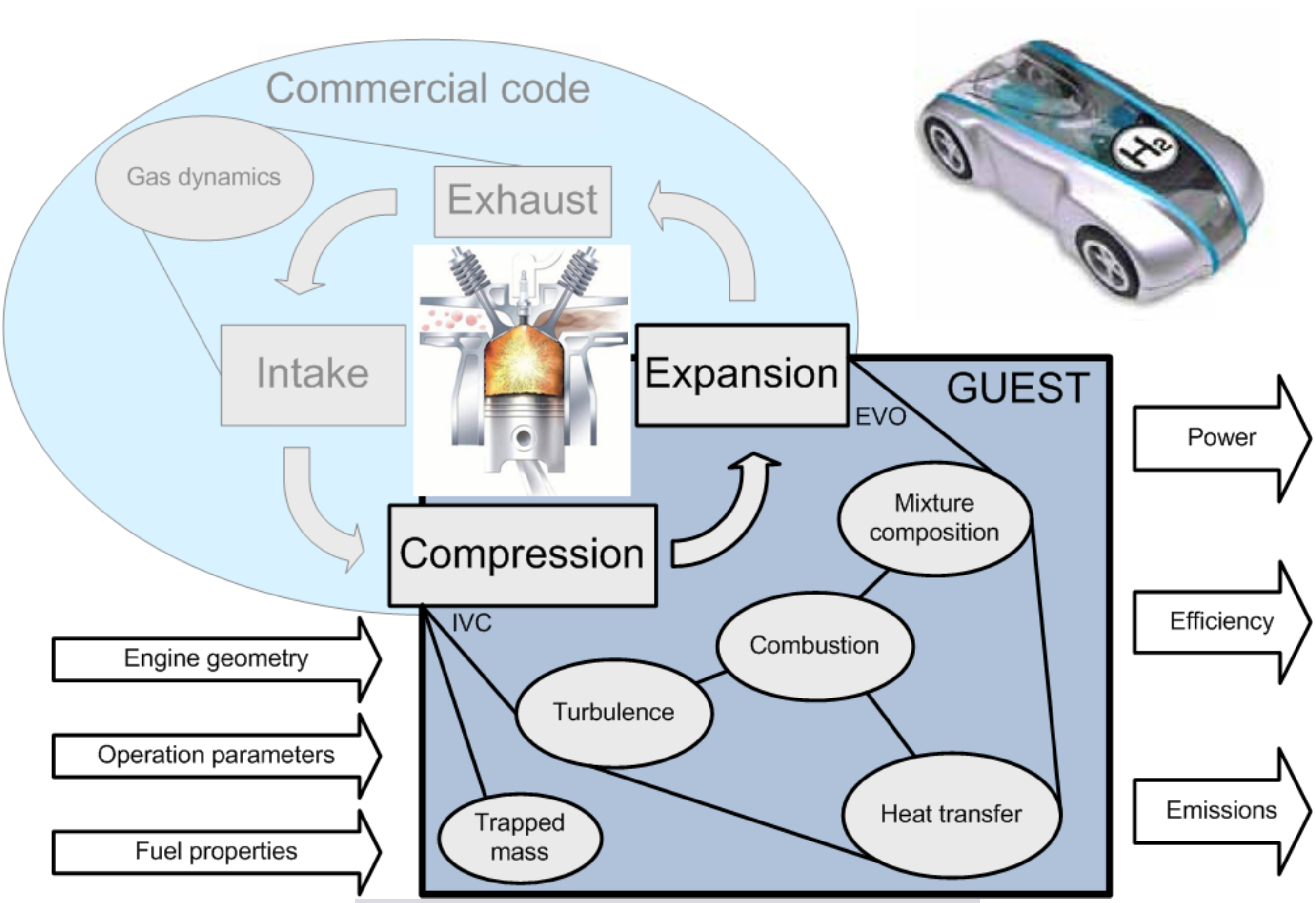
Engine Simulation Tool

Ghent University Engine Simulation Tool (GUEST) is an optimisation tool for SI engines. We work both on:

- 'Spark Ignition': hydrogen and (m)ethanol, (GEM) blends
- 'Compression Ignition': diesel, DME, oils, fats

We focus on measuring and modelling of the engine cycle:

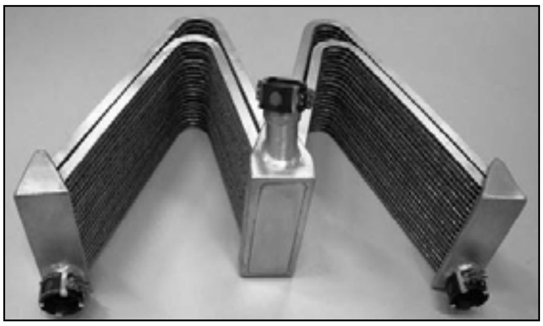
- Spray and mixture formation, combustion, heat transfer and emission formation
- Engine data for study of exhaust aftertreatment, CHP, hybrids, …
- 2 single cylinder test benches, multicylinder production engines, 5 engine dyno's, flow bench, GUCCI set-up

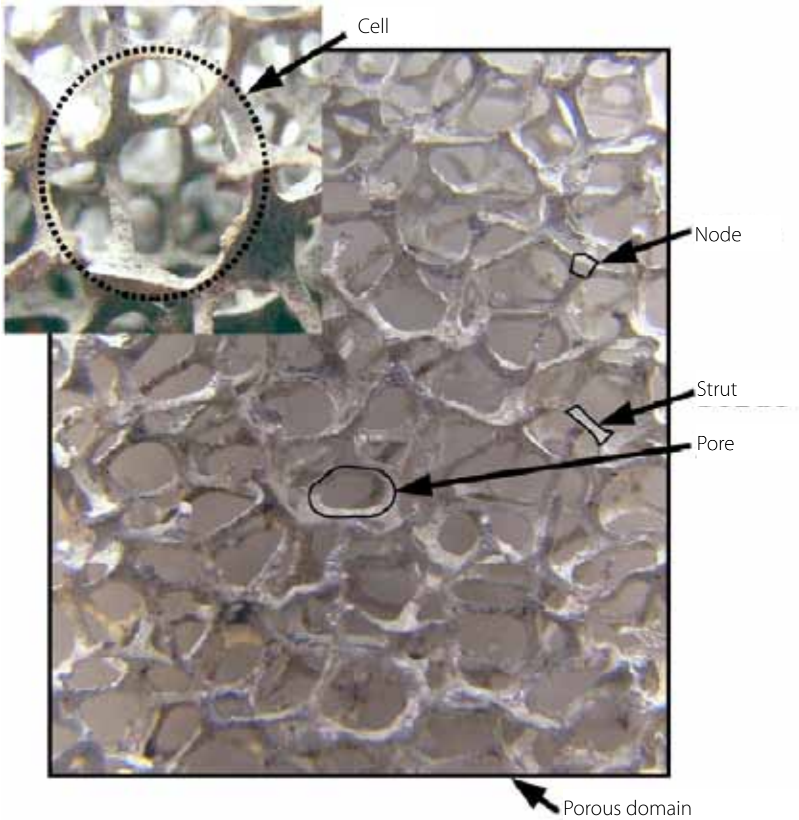


For further information, contact jeroen.demaeyer@ugent.be

Metal foam heat exchanger

Open cell metal foam with a high porosity (90% to 98%) is a very lightweight type of material that is very well suited to create efficient heat exchangers with very nice USP.
We are focussing on the design of metal foam based heat exchangers for challenging thermal solutions. We developed dedicated software to do so efficiently.
We have been developing several prototypes such as metal foam HEX for automotive LED cooling and cooling water.





For further information, contact jeroen.demaeyer@ugent.be

Tribological characterisation of advanced friction and wear materials

Laboratory Soete is well equipped to perform tribological characterisation of advanced friction and wear materials such as engineering polymers, composites, ceramics and others as used for e.g. bearings, hinges, brakes, ...
Different contact geometries (point, line, flat), load and sliding conditions can be applied. 15 different tribotesters are at disposal.
Tests can also provide data for friction and wear models to be used for lifetime design. Friction, friction stability and wear models are developed.

High temperature (1000 °C) tribometer

Friction stability tester

For further information, contact patrick.debaets@ugent.be

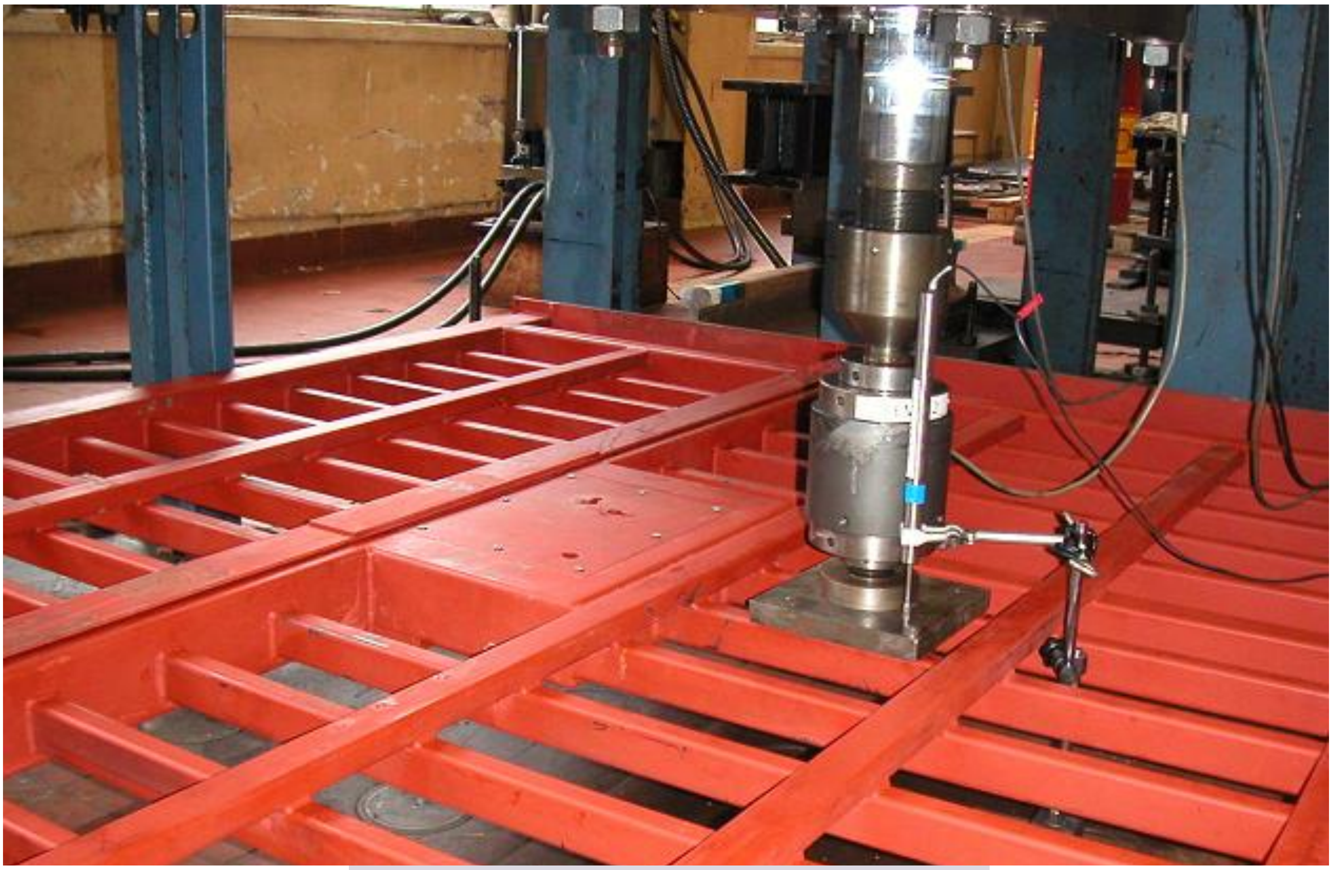
Fatigue behaviour of large structures and machine components

Laboratory Soete has a long tradition in fatigue testing. Material coupons, machine components and also large structures can be tested. The lab is equipped with traditional tensile fatigue load frames but is also equipped with a strong floor. In a modular way up to 8 actuators (from 50 kN to 1400 kN) can simultaneously be controlled for performing dynamic fatigue testing.

The lab is specialized in investigating production and assembly influence on fatigue resistance of structures. Features of interest are welds, bolted connections .

For some years now also numerical models have been developed for describing fatigue initiation andpropoagation, including surface effects such as e.g. microtopography and wear.

Dynamic testing of steel structure on modular floor

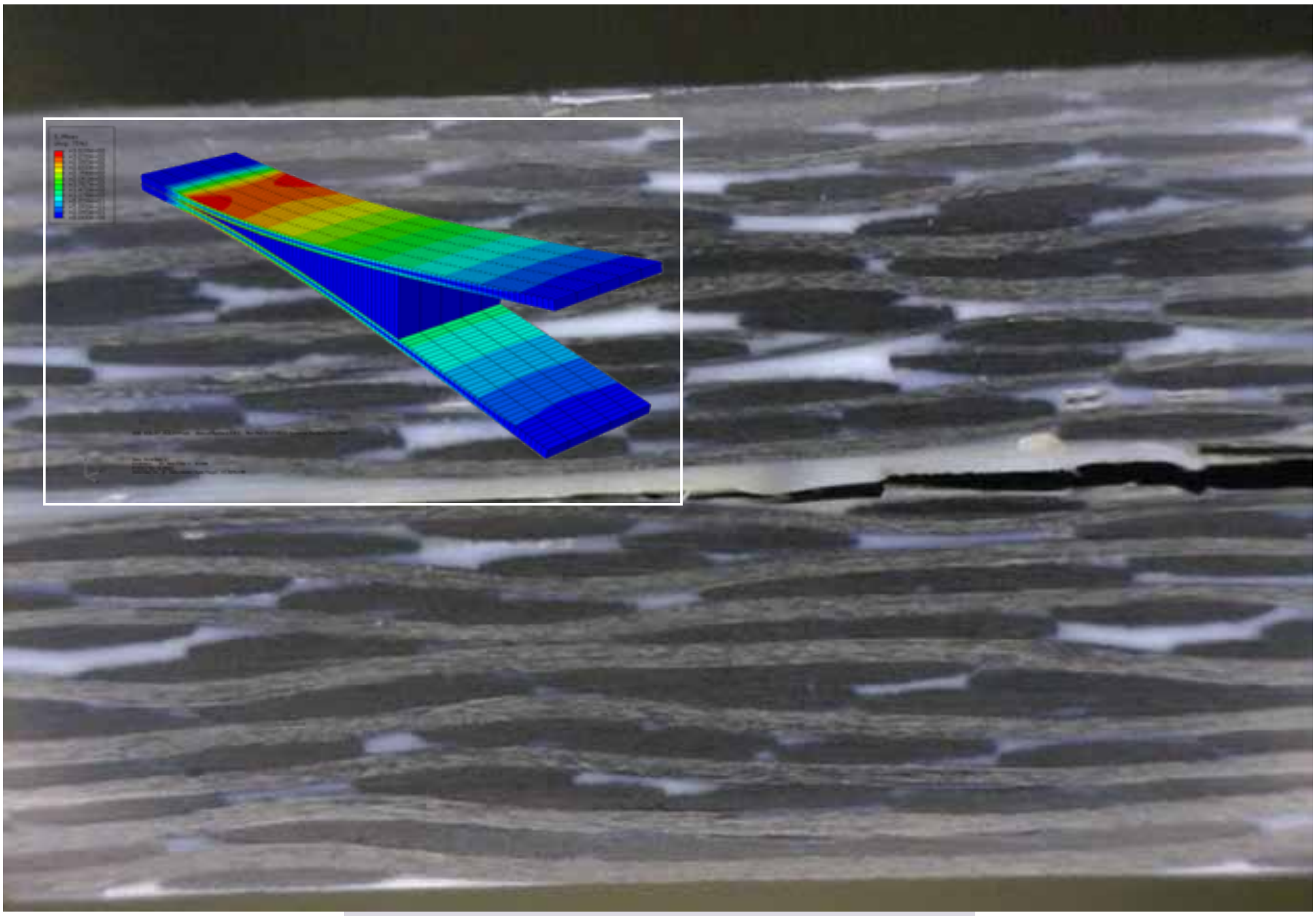


For further information, contact patrick.debaets@ugent.be

Joining of materials

Research focuses both on adhesive joints between similar or dissimilar materials and on fusion bonding of thermoplastic composites. We have experience in the following areas:

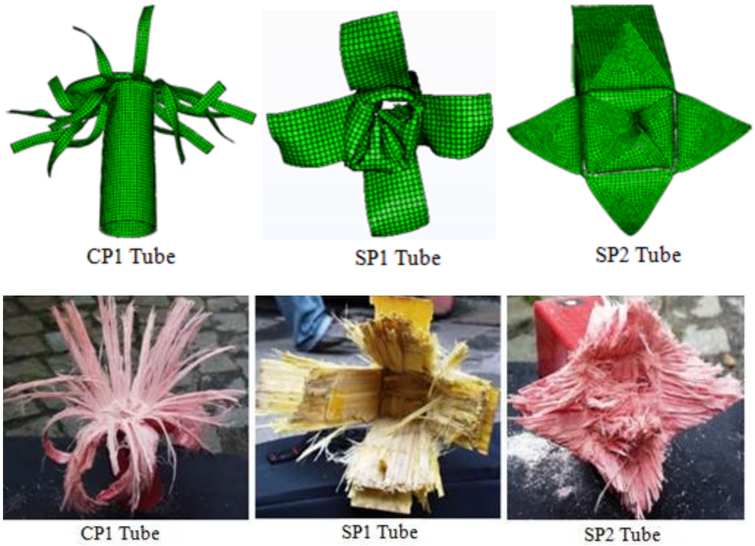
- Design and simulation of the stress distribution in and fracture behaviour of adhesive joints
- Mechanical testing through single and double lap shear tests, peel tests, ... and instrumentation with online video-microscopy
- Measurement of the fracture toughness in mode I, Mode II, ...
- NDT through ultrasound inspection, embedded optical fibre sensors



For further information, contact ilse.christiaens@ugent.be

Impact behaviour of composites

Extensive experience on the modelling of impact behaviour by finite element simulation. This expertise is combined with experimental equipment to allow for static and dynamic crushing of composite tubes.
The setup is fully instrumented to measure contact force, decelerations and energy absorption and is equipped with a high speed digital camera to follow the deformation.



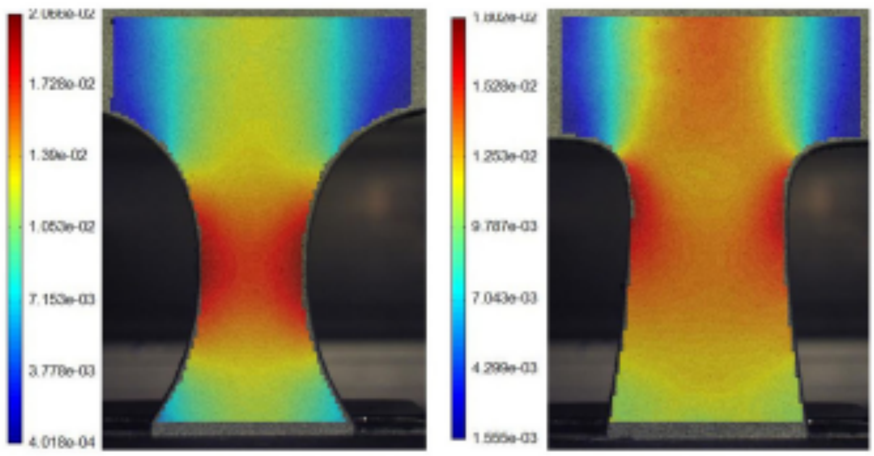
For further information, contact ilse.christiaens@ugent.be

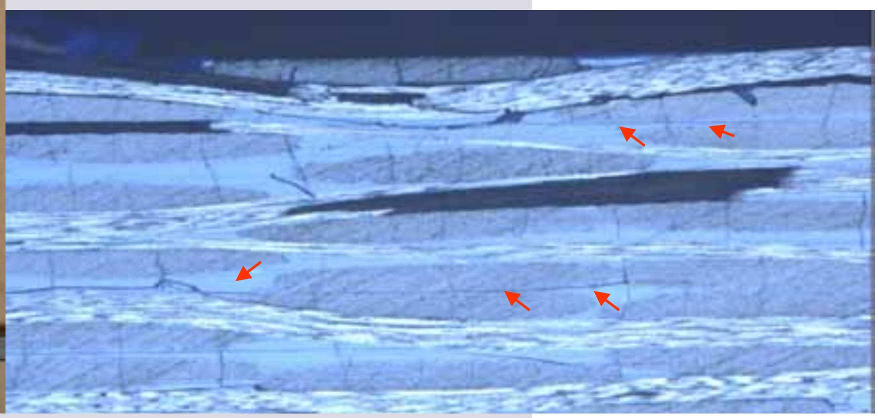
Fatigue behaviour of composites

We have extensive experience in the modelling and experimental study of the fatigue behaviour of fibre-reinforced plastics in tension, compression, bending and shear.

Fatigue tests are instrumented with extensometers, (embedded) optical fibre sensors, online video-microscopy, Digital Image Correlation,..

Post-mortem inspection is done by optical and electron microscopy (SEM).





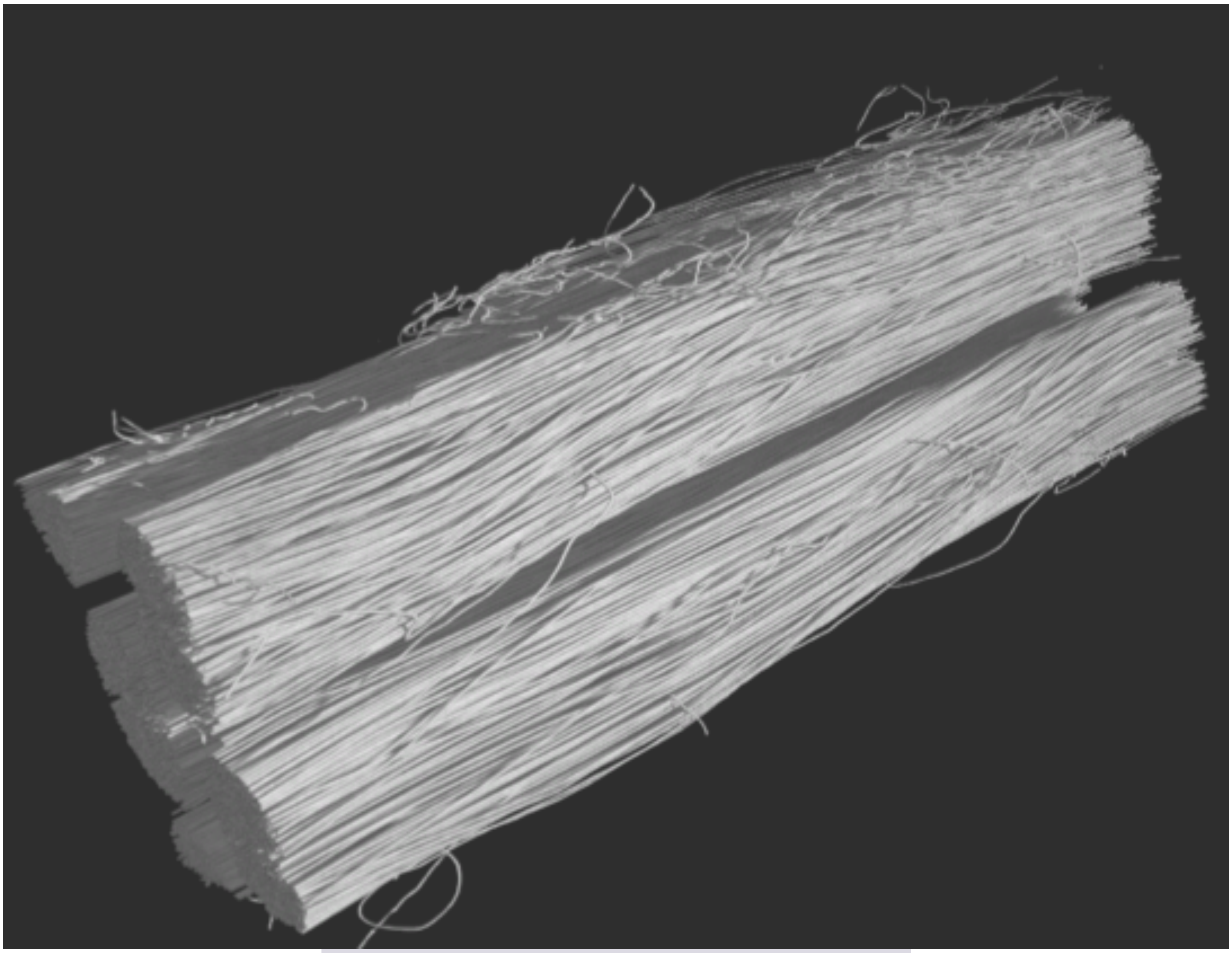
For further information, contact ilse.christiaens@ugent.be

Steel fiber reinforced composites

Together with Bekaert company, we are working on steel fiber reinforced composites where the steel fiber has a diameter of down to 30 micron. The goal is to optimally exploit the toughness of the steel fibers compared to classical fibers such as glass or carbon. At the same time this kind of composite is electrically conductant and relieves issues of static charging.

Our main focus is on the modelling of this composite of which the fiber shows significant plastic behaviour.

Other hybrid composites with steel cord have been successfully applied in bumper applications for structural integrity during crash.

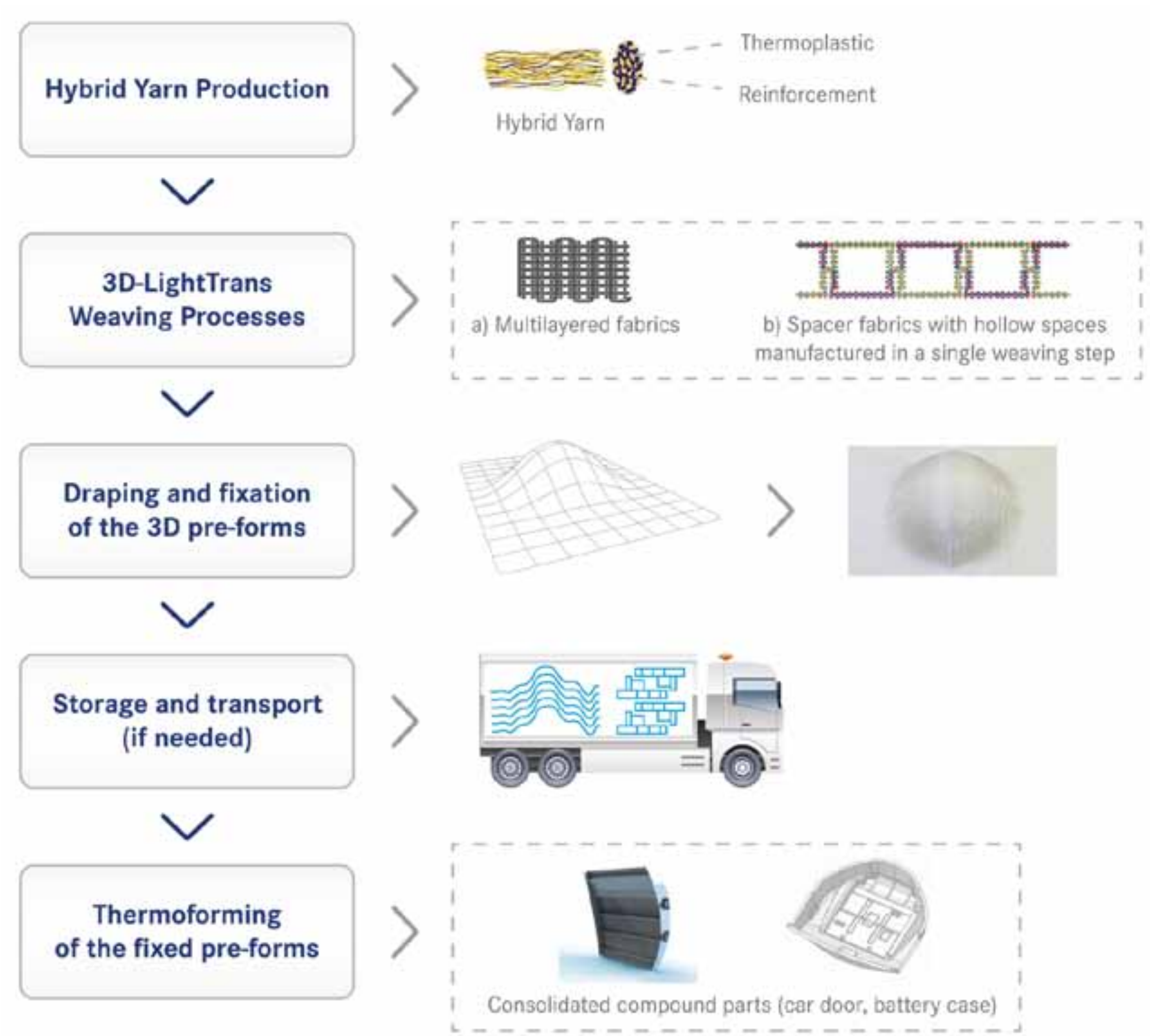


For further information, contact ilse.christiaens@ugent.be

3D woven thermoplastic composites

The project 3D-LightTrans aims to provide a ground-breaking, highly flexible, efficient and adaptable manufacturing chain for the production of integral large scale 3D textile reinforced plastic composites (TRPC) for automotive applications.

This will enable to shift them from their current position in cost intensive, small series niche markets, to broadly extended mass product applications in transportation and other key sectors, like health and leisure.



For further information, contact ilse.christiaens@ugent.be

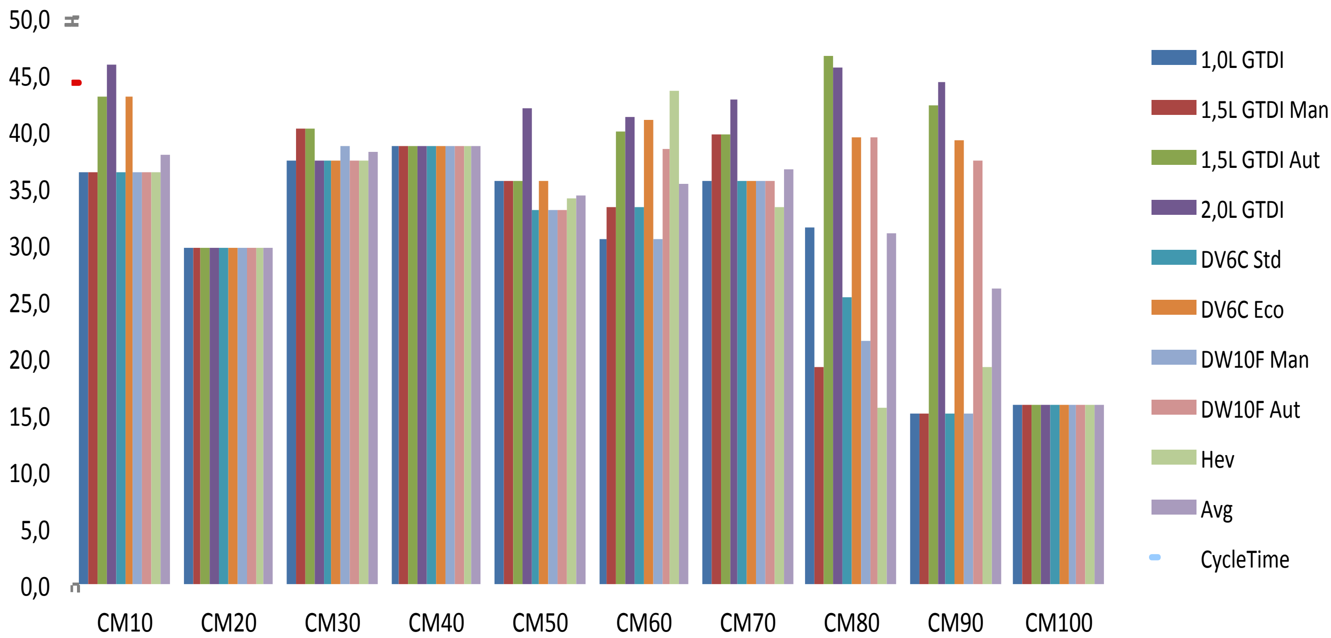
Complexity analysis of production lines

COMPLEXITY is a methodology which monitors single and multiple operator activity around a workstation in operation and reports on the overall complexity of the observed process. COMPLEXITY uncovers in detail the subprocess(es) which impact most on performance, e.g. time lost due to reading of instructions in a flexible supply chain, bad organization of tools within the workspace, too many assembly directions, too much distance between parts. The methodology is supported by a camera monitoring system which through automated computer vision aids in the reporting.

For further information, contact hendrik.vanlandeghem@ugent.be

Assembly line balancing with variant models

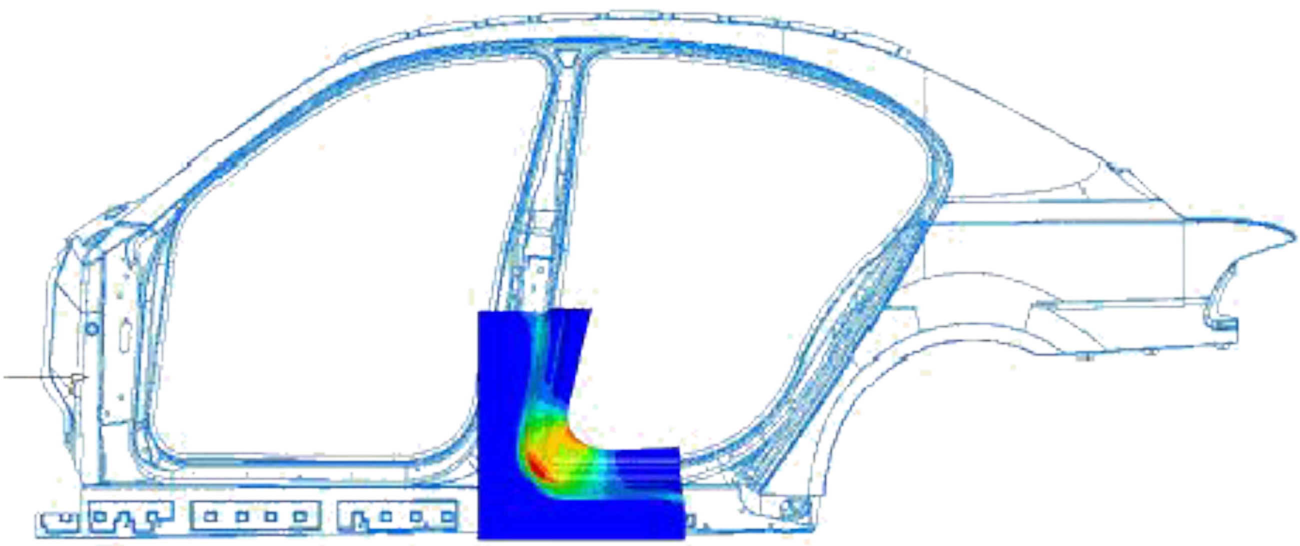
We developed an algorithm that will balance the work elements along an assembly line, with multiple operators per workstation, taking into account variant models on the line. Variants lead to varying workload in most workstations along the line, and the algorithm will minimize this variance. The result is a workload which is less sensitive to the sequence of models that will be put on the line.



For further information, contact hendrik.vanlandeghem@ugent.be

Surrogate model software to tackle the increasing automotive design complexity

The SUMO Lab develops highly tuned Surrogate Model software to use together with your existing, traditional simulation tools. Since more than 10 years, we apply and evaluate novel machine learning techniques, adaptive sampling and adaptive model strategies, and bundle these into the latest releases of the SUMO toolbox.
With the SUMO toolbox, we tackle the increasing complexity in the multidisciplinary automotive design process. One example is the car body design, where the existence of cracks needs to be minimized. Another example is the modeling of crash helmet tests.

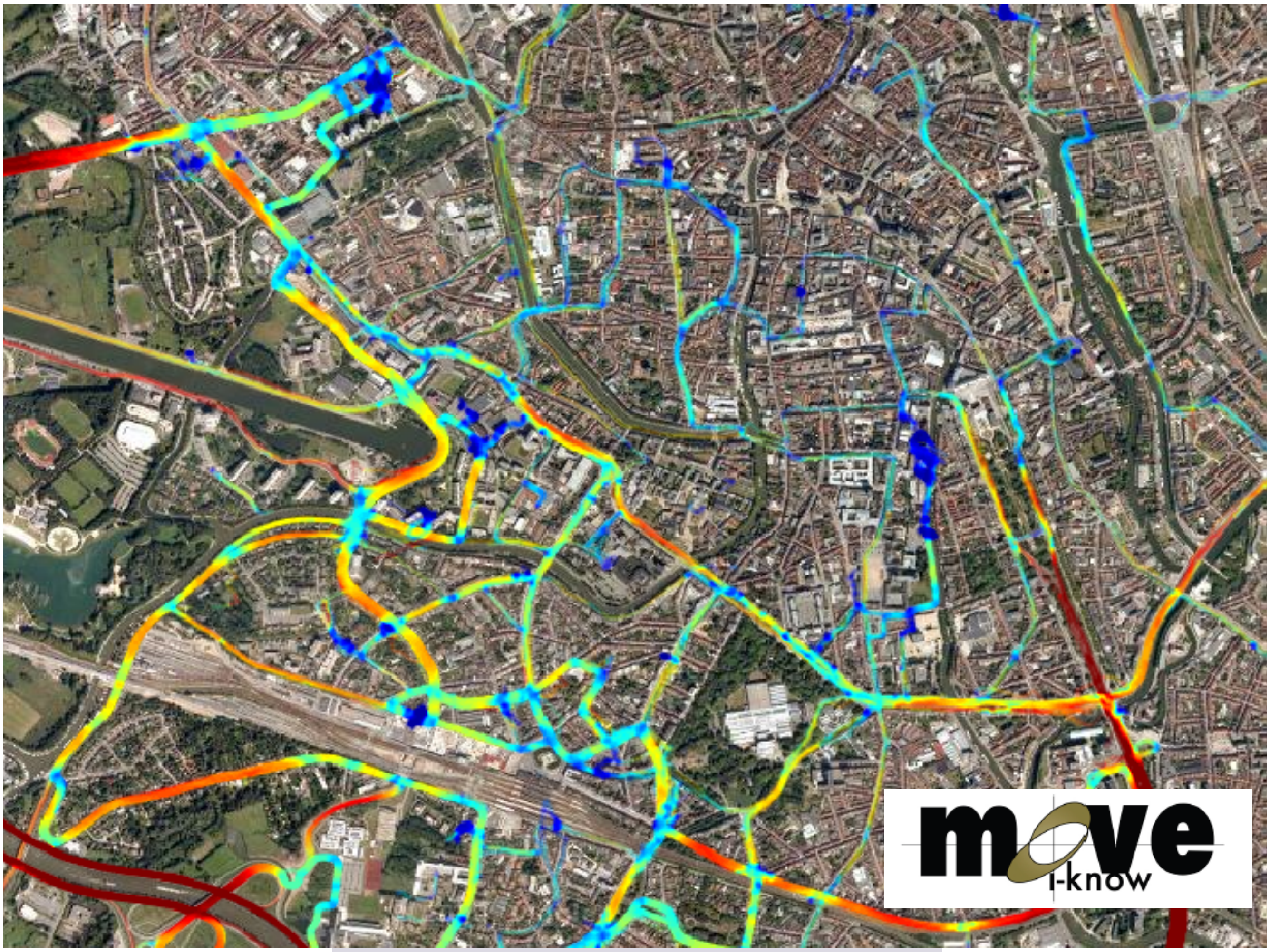


Car body design minimizing the exsitence of cracks and unacceptable thinning

For further information, contact wouter.haerick@ugent.be

Analysis of driving behaviour

MOVE is a business intelligence solution that analyses spatial behaviour of people over different transport modes: car, public transport, bicycles and pedestrians. It connects with data coming from vehicle navigation and tracking systems. MOVE offers a propietary software core for battery-efficient smartphone monitoring over different mobile sensors, which allows to monitor full mobility trips. MOVE reports on the driving and travel behaviour of people in relation to the current traffic situation, weather conditions and travel purpose.

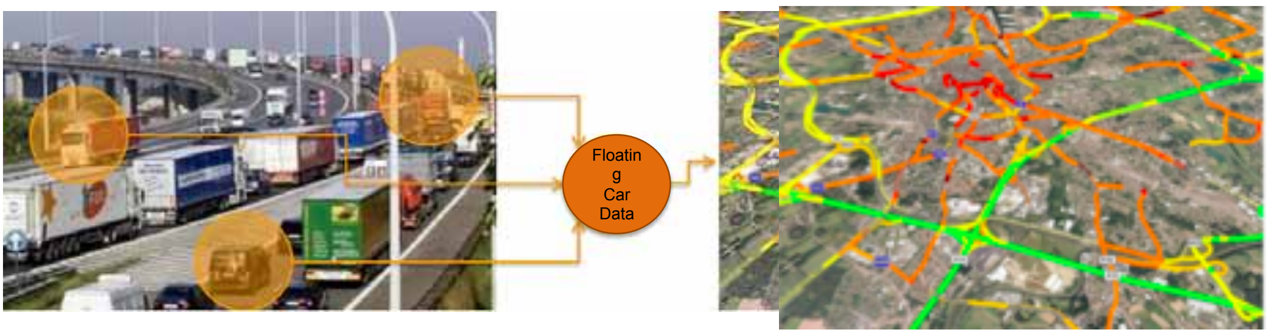


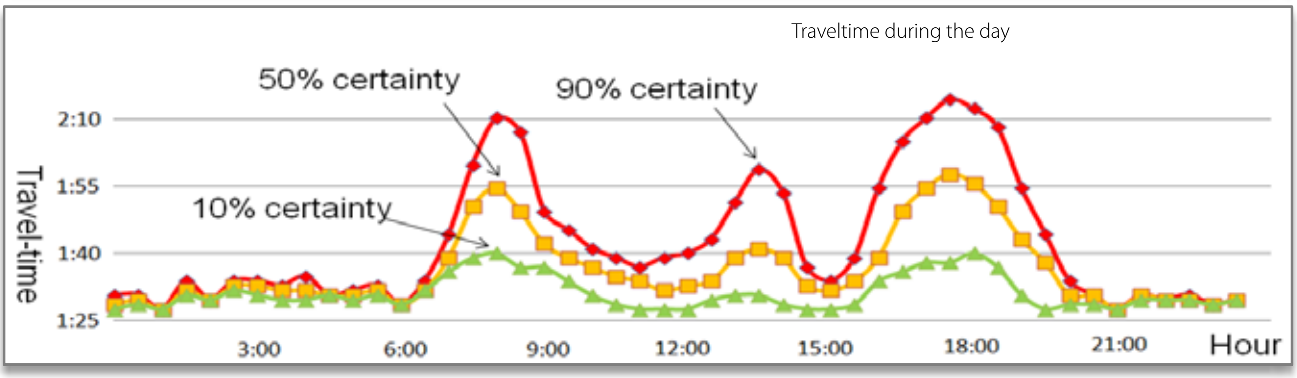
For further information, contact sidharta.gautama@ugent.be

Optimizing realtime, multimodal routing software

At Ghent University we develop multimodal routing algorithms, applying deep expertise in communication network routing algorithms. We design and optimize realtime statistical computation models to transform floating car data into meaningful information for drivers, or for control centers of logistics companies.

In our models, we make a trade-off between confidence levels and computational performance, tailored to the dynamic needs of the end-user. As we manage to predict arrival times accurately, these outputs can also be used for electric vehicles charging optimization.





For further information, contact wouter.haerick@ugent.be

Scalable vehicle-to-vehicle communication

Ghent University has a unique ITS Lab where Intelligent Transport Systems (ITS) are evaluated and optimized. With the lab equipment real-life communication experiments can be monitored, as well as large scale traffic patterns can be simulated and evaluated.

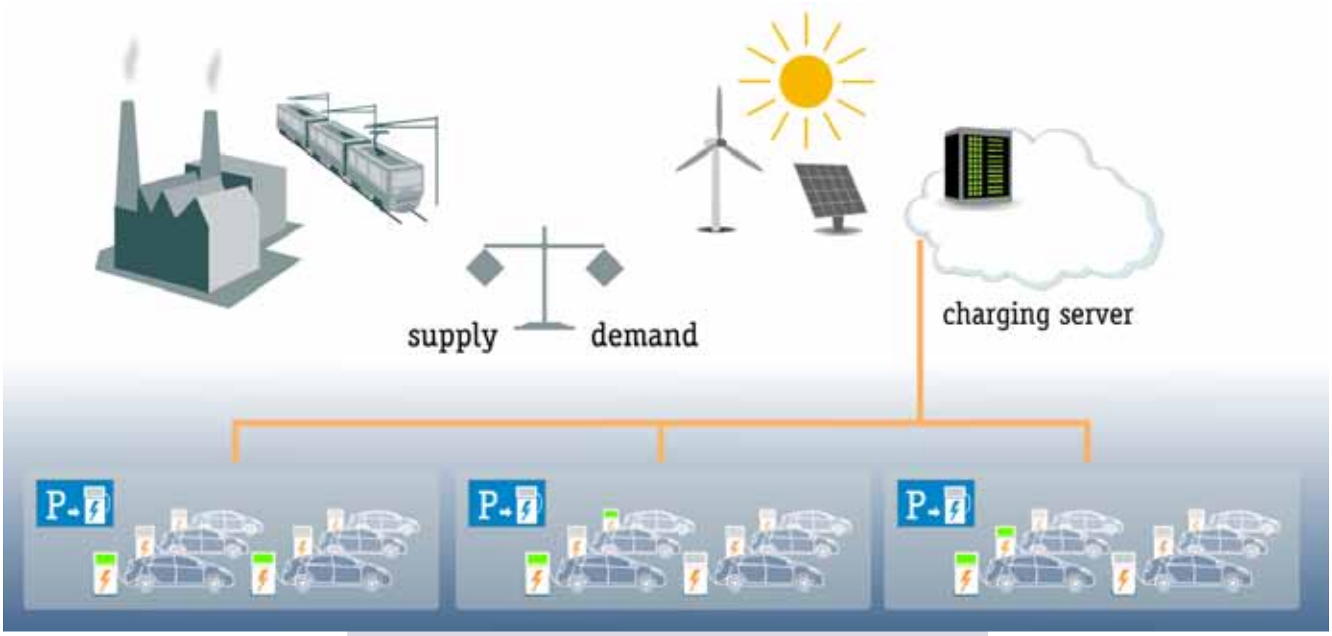
The ITS Lab is focussing on the robustness and scalability of the wireless communication protocols and infrastructure, as well as on the design of end-user apps for traffic collision avoidance, safety and mobility.

For further information, contact wouter.haerick@ugent.be

Smart electric vehicle charging

Given the challenges of the volatile renewable energy production, and the high expected electricity demand of electric vehicles loading simultaneously, novel algorithms are needed to optimize reuse of green energy while minimizing the load on the public electricity grid.

Ghent University is developing cutting-edge algorithms that optimize the usage of nearby wind energy to charge cars in large city parkings, taking into account customer preferences and grid constraints. Together with the different stakeholders, we develop scalable architectures where the necessary information can be exchanged to minimize operational costs, and future investments.



For further information, contact wouter.haerick@ugent.be

Textiles

Our accredited textile laboratory performs standardized tests on all kinds of automotive indoor materials such as floor mats, trim materials, dashboard covers, door panels, etc.
A wide range of tests can be performed on physical, chemical and flammability properties. Such as, but not limited to: as strength, abrasion resistance, colour fastness, resistance to staining, clipping force, fire resistance (e.g. FMVSS test), fogging, ageing, rigidity, ...
These tests are performed according to standards for car and truck brands: such as Toyota, Ford, GME, Volkswagen, Renault, Peugeot, Volvo, Nissan; and also according to international standards such as ISO or SAE.
Additionally we help companies to develop new materials such as non-wovens for heat and sound insulation or composite structures.

Clipping force of eyelets

Taber tester for abrasion resistance

Flammability test for floorcoverings

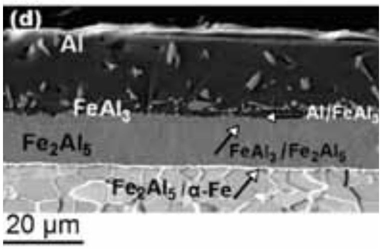
For further information contact Johanna.louwagie@ugent.be

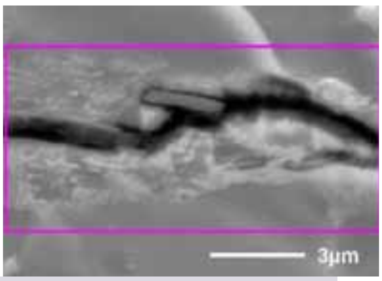
Corrosion and surface engineering

As the use of materials has become ubiquitous and extremely versatile, they are exposed to an enormous diversity of environments. Quite frequently, this interaction has a detrimental influence on the mechanical, physical or esthetical properties of the materials that are used. A better understanding of the phenomena, governing this impact of the environment on the material, will help to increase the life span of the products and constructions in which these materials are used.

Specific research areas are investigated in the frame of fundamental research programs as well as in collaboration with industrial partners:

- Interaction of hydrogen with high strength alloys and its effect on the material performance;
- Development/characterization of metallic coatings for steel substrates making use of a laboratory set-up for hot-dip process simulation;
- Investigation of the basic physical metallurgical features governing corrosion;
- Accelerated corrosion test by salt spray testing in standardized conditions.



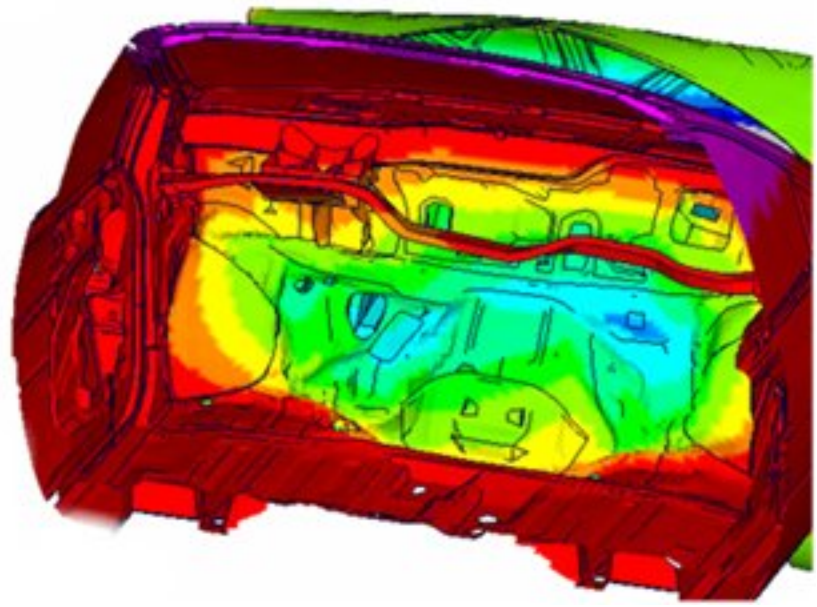


1. Rhesca hot dip simulator
2. Set-up salt spray experiments
3. SEM cross section of the intermetallics formed after 20 s in a Al + 1 wt.% Si bath at 700°C.
4. Hydrogen induced cracking along a MnS inclusion

For further information, contact: Ilse.Christiaens@UGent.be

Impact

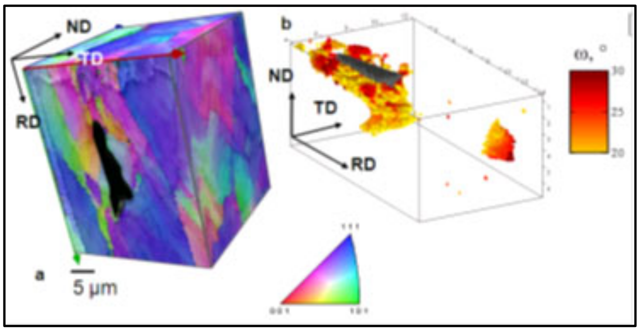
During a car crash or collision, the car body is subjected to very high strain rates. Under such impact-dynamic conditions, metal alloys tend to exhibit higher strength levels, albeit at the expense of deformation capacity. As a result, the strength and energy absorption potential of metallic car components are strongly dependent on the rate of deformation. We offer access to state-of-the-art experimental facilities to study the dynamic behavior of materials. Our Hopkinson test set-ups can subject materials to very high strain rates in tension, compression, torsion, combined torsion-compression and shear. The experimental results enable a better understanding of the dynamic response of high strength steel alloys, aluminium, titanium and other materials. In addition, these results are used to model the material behavior and predict their response during dynamic events like a car crash. We have measured and modeled the dynamic properties of Dual Phase (DP) steels, Transformation Induced Plasticity (TRIP) steels, austenitic stainless steels, martensitic steels, TWIP steels, aluminium alloys, titanium alloys , ... The results have been used in the design of an Ultra Light Auto Body (ULSAB) structure, and turbine blade failure.



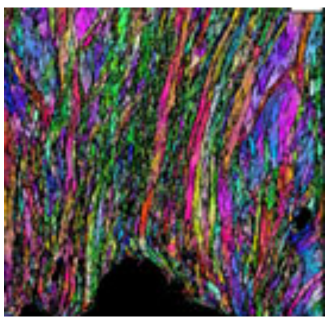
For further information, contact: Ilse.Christiaens@UGent.be

Materials characterization and damage analysis

We are specialized in characterization of microstructures and crystallographic aspects of the deformation and damage behaviour of specific materials for automotive applications. These materials include steels (interstitial free (IF), low carbon and extra low carbon (LC, ELS), dual phase (DP), transformation induced plasticity (TRIP), twinning induced plasticity (TWIP), maraging steels and many others), cast iron for cylinder blocks, Al alloys for inner and outer panels , Mg and Ti alloys.
We offer our expertise in characterizing the microstructure and properties by means of classical characterization techniques like optical microscopy, scanning electron microscopy, X-ray diffraction and transmission electron microscopy and advanced techniques like electron backscatter diffraction (EBSD) in 2D and 3D in small (20x20x20μm^3) and large (up to a few mm) samples.



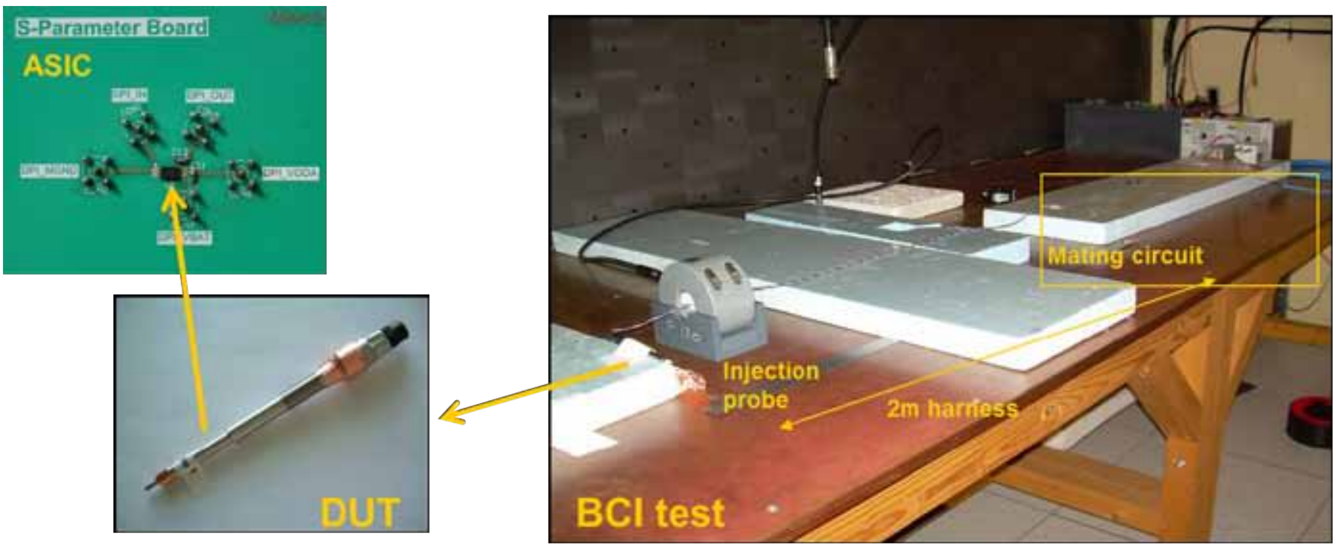
Tensile test of an IF steel and optical micrograph of a non-metallic inclusion. The colour maps are obtained by electron backscatter diffraction in 3D and 2D. The microstructure is coloured with respect to its crystallographic orientation and provides important information for the better understanding the damage and fracture in the steels.



For further information, contact: ilse.christiaens@ugent.be

Electro-Magnetic Compatibility and Signal Integrity

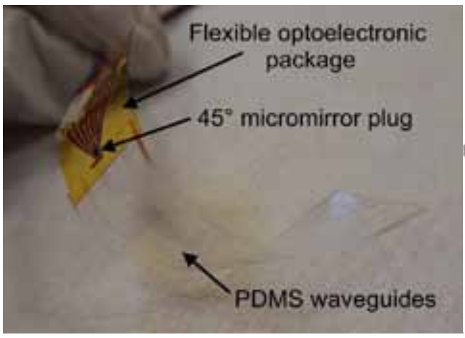
State-of-the-art automotive components are subject to ever stricter requirements in terms of Electro-Magnetic Compatibility (EMC) and Signal Integrity (SI). In this context, suppliers of electronics for automotive are required to provide behavioral models describing the response of their components to desired and parasitic signals. In addition, to ensure EMC and SI in the final application (being inside the vehicle), electronics suppliers must be able to foresee EMC and SI problems already during the design phase. The EM group of Ghent University has the necessary expertise, measurement and modeling tools to construct such behavioral component models that can be integrated in tools simulating EMC and SI problems in the client's application, in the same time protecting the intellectual property of the supplier. In addition, the group offers EMC and SI consultancy, acting as an independent expert to scientifically settle EMC/SI disputes between suppliers and customers.

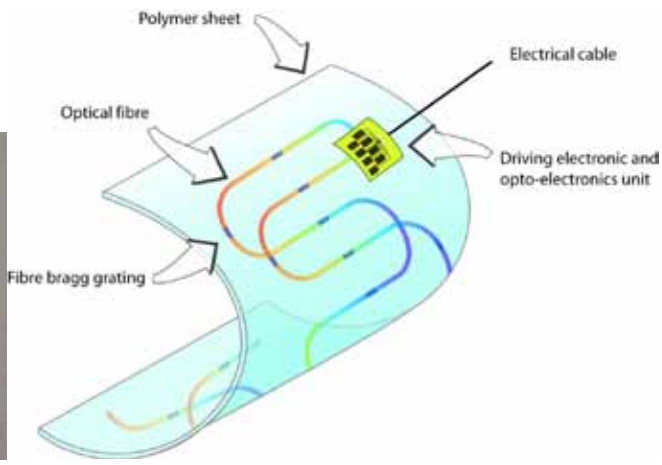


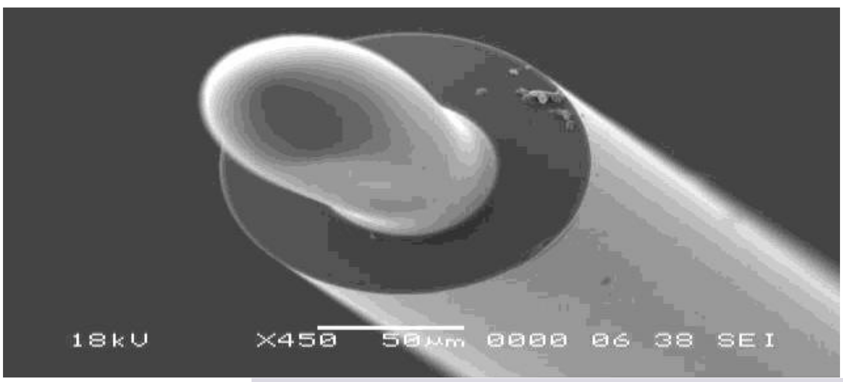
For further information, contact: Frederik.Leys@ugent.be

Polymer optical waveguide technology

Polymer based optical fibers are well suited for short range optical data transmission in automotive applications. They are simpler to handle compared to glass fibers and mechanically more robust. We develop generic integration platforms to realize low-cost flexible or stretchable polymer based photonic sensors (including pressure, shear and gas sensors) and interconnection technology for optical data communication such as self-written waveguides for fiber to fiber connectivity. In the framework of the EU-project PHOSFOS, the integration technology was developed to embed all the building blocks of a dynamic fiber Bragg sensing system in a flexible polymer pad. Dynamic measurements could be demonstrated using an ultra-compact interrogation concept. See http://www.phosfos.eu or www.cmst.be for more information.



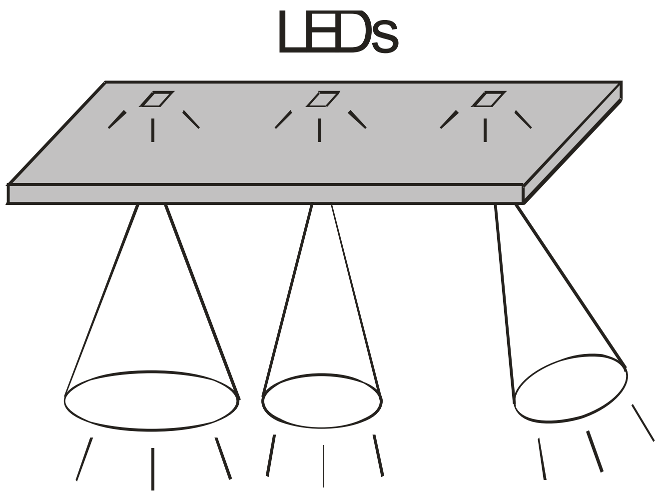




For further information, contact: Frederik.Leys@ugent.be

LC based light steering components

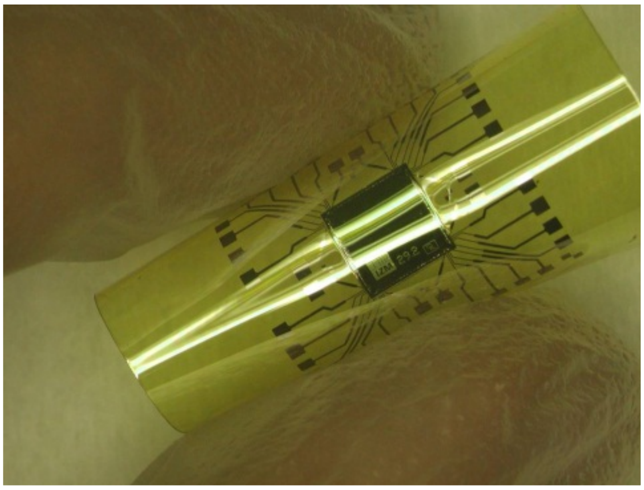
Dynamic manipulation of the direction or focus of a bundle of light is a vital functionality for a wide range of photonic applications, such as adaptive headlights for cars. Current methods to achieve this functionality are still mainly based on mechanical motion of mirrors or lenses. We investigate the combination of (multiple) micro-structured polymer components with novel liquid crystals to realize light steering films with a wide steering range, a high steering angle resolution and adaptive optical functionalities beyond state-of-the-art.
We also offer expertise on solid state projection and driver technology for smart cockpit applications, see https://www.odicis.org/ or www.cmst.be for more information.

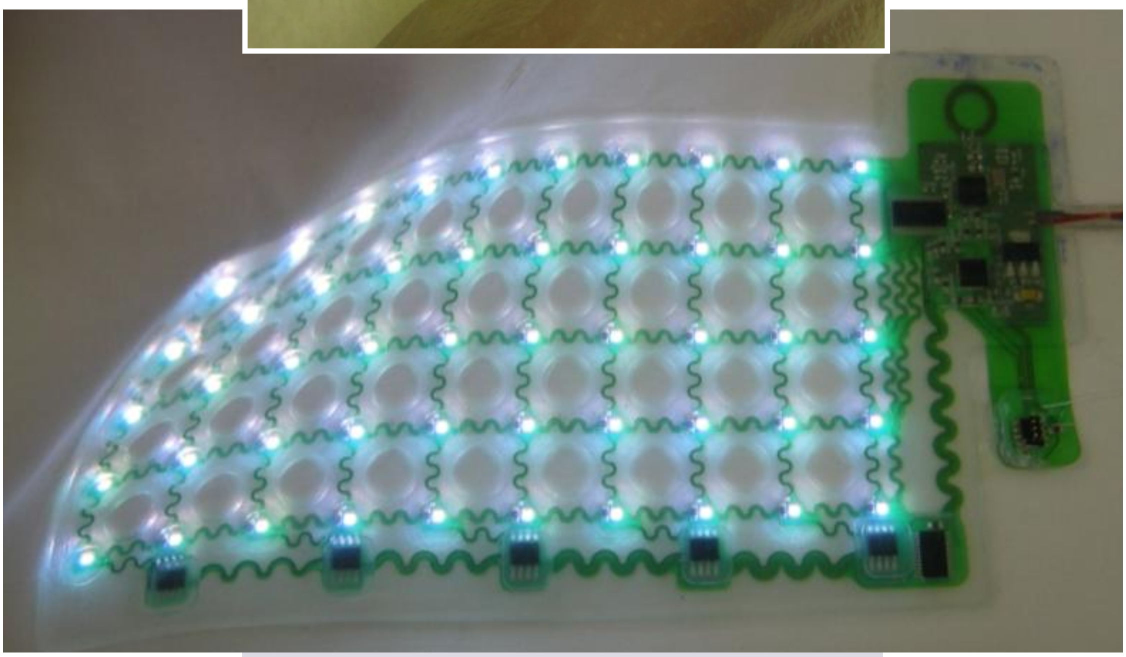


For further information, contact: Frederik.Leys@ugent.be

Stretchable interconnection and ultra-thin chip packaging technology

We offer mature and upscalable technology platforms for ultra-thin chip packaging (~50µm total thickness) and deformable electronic interconnections. Together with industrial partners we work on the integration of stretchable electronics in car head liners (led arrays) and passenger seats (temperature & seat-occupation sensors) and of one-time deformable electronics in rigid thermo-formed interior panels. Our technology platform for deformable interconnections is compatible with standard PCB processing. See http://www.pasta-project.eu/, http://www.place-it-project.eu/ or www.cmst.be for more information.



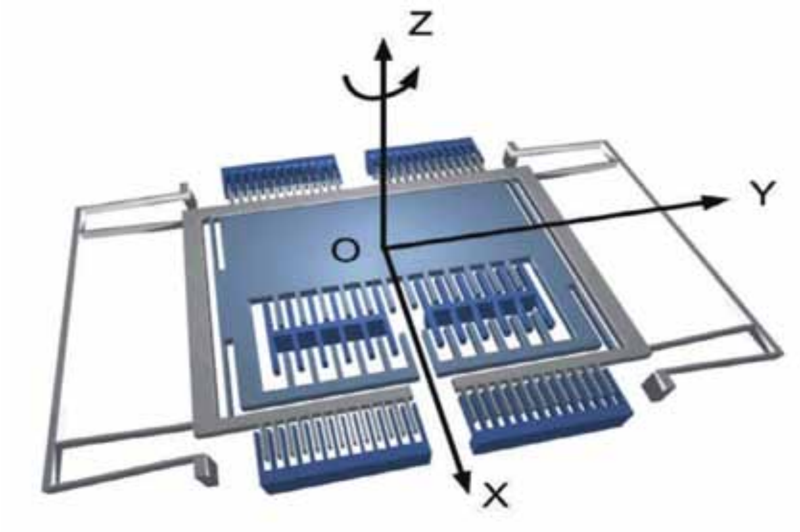


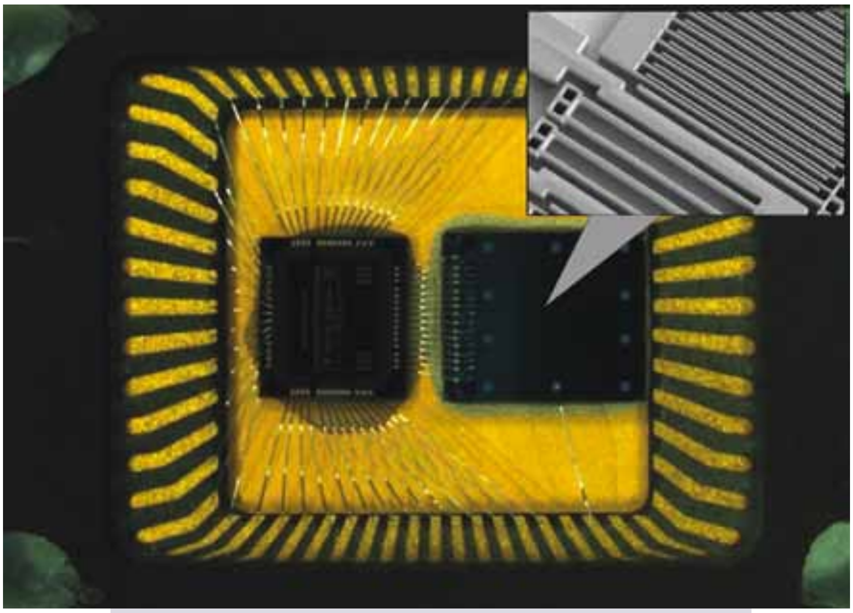
For further information, contact: Frederik.Leys@ugent.be

System design for MEMS inertial sensors

The research group "Circuits and Systems" has developed a unique design methodology enabling the fast, adaptive and robust design of micro electromechanical inertial sensors for commercial use.

This design methodology has been validated by the development of MEMS for the measurement of inertial forces: both for acceleration (accelerometer) and rotation (gyroscope). The developed prototypes consist of a mechanical chip that is connected to an electrical chip. The mechanical chips consist of moving micromasses that are connected with springs. The electrical chips provide full closed loop sensor control for robust performance over temperature variations and time.





For more information, please contact: Pieter.Rombouts@ugent.be

Faculty of Engineering and Architecture

The activities reported in this brochure all originate from the faculty of Engineering and Architecture. The faculty of Engineering and Architecture has more than 2200 students, 150 professors and 800 researchers. It is one of the major faculties of Ghent University, Belgium.
Unlike similar schools abroad, the faculty is not divided in education linked divisions. Its 15 departments are organised around research topics and are involved in different study programmes offered by the Faculty of Engineering and Architecture. The departments contributing to automotive research and engineering are:

- Department of Flow, Heat and Combustion Mechanics
- Department of Mechanical Construction and Production
- Department of Information Technology
- Department of Telecommunications and Information Processing
- Department of Electrical Energy, Systems and Automation
- Department of Materials Science and Engineering
- Department of Industrial Management

For more information: prof. Sebastian Verhelst, research group Transport Technology, sebastian.verhelst@ugent.be – tel. +32(0)92643306

The Ghent Innovation hub

In Ghent, more than 6.000 researchers covering more than 80 nationalities are involved in basic research, working at the Ghent University Association, the Ghent University Hospital, or at one of the strategic research institutes VIB (Flemish Institute for Biotechology) or IBBT (Interdisciplinary Institute for Broadband Technology).
In 2010, they together realized an R&D investment of more than 300 million euros, of which more than 30% was financed by industry, indicating the strong collaboration with companies worldwide.
The Ghent region is also an important economic hub within one hour drive from the capital of the European Union. It is home to a diversity of commercial and industrial activities thanks partly to the proximity of the Port of Ghent. Established businesses like steel mills, paper mills, car assembly, navigation software, speech technologies and biofuel processing go hand in hand with clusters of new high-tech companies. Several applied research centers and semi-industrial pilot plants, created as joint-ventures between industry and academia, stimulate innovation in areas such as biofuels, new steel applications, and materials.
For more information:
www.techtransfer.ugent.be – techtransfer@ugent.be

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